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Antibiotic residues in poultry and food safety risks in North Cotabato, Philippines

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Abstract. *Hadji Ibrahim AB, Jumao-As CM, Tampus AD, Tabugo SRM, Adamat LA, Jose MAI, Tanabe MEN, Amparado OA. 2025. Antibiotic residues in poultry and food safety risks in North Cotabato, Philippines. Asian J Agric 9: 463-471.* Poultry production in North Cotabato, Philippines, remains a key agricultural sector, yet the extent of antimicrobial residue contamination in retail chicken meat is poorly documented. This study aimed to detect and quantify antibiotic residues in organic and non-organic chicken meat sold in public wet markets using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Thirty-six whole dressed chickens (18 organic and 18 non-organic) were purchased across six municipalities, yielding 72 tissue samples (wings and legs). Six antibiotics namely doxycycline, enrofloxacin, norfloxacin, tilmicosin, amoxicillin, and trimethoprim/sulfamethoxazole were targeted. Doxycycline was the most frequently detected compound, present in 100% of non-organic and 50% of organic samples. Fluoroquinolones (enrofloxacin/norfloxacin) and tilmicosin (macrolide) were detected exclusively in non-organic leg tissues at frequencies of 66.7% and 50%, respectively. Residue concentrations ranged from <1.5 μg/kg to 37.2 μg/kg, with all values below Maximum Residue Limits (MRLs). No samples contained amoxicillin or trimethoprim/sulfamethoxazole. While a two-way ANOVA revealed no significant differences in mean residue concentrations by chicken part or production type ($p>0.05$), Chi-square tests revealed significant differences in detection frequency by production type ($p<0.001$) and by municipality ($p=0.029$). Non-organic samples consistently exhibited higher detection rates, with Pikit and Pigkawayan identified as geographic hotspots. These findings expose gaps in residue withdrawal compliance, certification credibility, and traceability in informal retail markets. The detection of residues in uncertified “organic” chicken underscores the urgent need for strengthened organic certification enforcement, farmer education, and municipality-level surveillance to align with the Philippine AMR Action Plan and ASEAN regional goals.

Keywords: Antimicrobial residues, chicken meat, LC-MS/MS, North Cotabato, QuEChERS method

INTRODUCTION

Poultry farming is one of the leading agricultural enterprises in North Cotabato, Philippines, accounting for a significant share of the province’s food production and meeting the growing demand for affordable animal protein (BAI 2021). As in many other regions of the country, poultry producers in North Cotabato often rely on antibiotics such as doxycycline, enrofloxacin, and tilmicosin for therapeutic, prophylactic, and growth-promoting purposes to sustain flock health and productivity (Barroga et al. 2020; Imperial et al. 2022). Although these practices improve short-term production efficiency, they also increase the risk of antibiotic residues persisting in edible poultry tissues, raising food safety concerns (WHO 2014; BAI 2021).

Several Philippine studies have documented the presence of antimicrobial residues in poultry products. Detection of residues of tetracycline, sulfonamides, penicillin, and aminoglycosides in broiler chicken tissues has been reported in both commercial and backyard producers (Baldrias et al. 2021), as well as in edible tissues (muscle, liver, gizzard) of broiler chickens sold in Tuguegarao City (Calagui 2016). Moreover, resistant *Escherichia coli* isolates have been recovered from poultry meat, linking antimicrobial use in production systems with residue persistence and resistance development (Imperial et al. 2022; Dimaapi et al. 2025). At the regional level, comparative studies have also shown that antibiotic residues and resistance can be detected in both organic and conventional poultry products, raising concerns about mislabeling and traceability in supposedly drug-free systems (Ager et al. 2023). Collectively, these findings emphasize that the ingestion of low-level residues over time can accelerate the emergence of resistant bacterial strains, threatening the effectiveness of antibiotics that remain critical to human medicine (Van Boeckel et al. 2019).

According to the Bureau of Animal Industry (BAI 2021), more than 670 metric tons of antimicrobials were used in Philippine livestock and poultry production in 2020, with tetracyclines, fluoroquinolones, macrolides, and β-lactams being the most reported classes. In North Cotabato, over-the-counter access and self-medication practices contribute to widespread antibiotic use, often without veterinary supervision or adherence to withdrawal periods, a pattern consistent with broader findings on veterinary drug use across the Philippines (Pineda-Cortel et al. 2024). These challenges are further compounded by structural gaps in agricultural extension and regulatory enforcement. Many smallholders depend on informal agro-veterinary suppliers for advice often without veterinary supervision or awareness of the risks of antimicrobial residues, a pattern reflected in studies of backyard poultry and swine production in the Philippines (FAO 2002; Barroga et al. 2020). Although Republic Act 10611, the Food Safety Act of 2013, provides a comprehensive framework for food safety regulation, its enforcement has been described as uneven, particularly in rural areas where veterinary laboratory capacity and residue testing infrastructure remain limited (Senate of the Philippines 2019; BAI 2021).

North Cotabato is a critical site for antibiotic residue research, given its role as one of Mindanao's top poultry-producing provinces, supplying both household consumption and commercial trade. Yet, even with studies like Mahusay and Sepelagio (2023) detecting residues in retailed meats from Kabacan public market, the province remains underrepresented in broader national surveillance efforts. Wet markets, which serve as the primary retail outlets for poultry among low- and middle-income households, heighten this concern. These markets typically lack cold-chain facilities, vendor knowledge of withdrawal regulations, and standardized product labeling, conditions that make them likely hotspots for antibiotic residues (ASEAN 2020). Compounding the issue, consumer demand for "organic" poultry has grown in recent years, in the Philippines, and while government regulations exist for certification, many products in rural markets are labeled "organic" based on vendor claims rather than third-party or accredited certification. This raises concerns about product authenticity, labeling fraud, and potential exposure to antibiotic or chemical residues (FAO 2002; Rappler 2024).

Given these gaps, this study was conducted to detect and quantify antibiotic residues in dressed chicken meat sold in public wet markets across six municipalities in North Cotabato using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Specifically, it aimed to identify the most frequently detected antibiotics, compare residue concentrations between organic and non-organic samples, and assess compliance with Maximum Residue Limits (MRLs) set by international standards. The findings are expected to provide locally relevant evidence to complement national food safety initiatives, inform antimicrobial resistance (AMR) policy actions, and guide farm-to-market interventions targeting both smallholder and commercial poultry systems in the Philippines.

MATERIALS AND METHODS

Pre-survey and antibiotic selection

To determine the most commonly used antibiotics in poultry and livestock production across the PPALMA municipalities (Pigcawayan, Pikit, Alamada, Libungan, Midsayap, and Aleosan) in North Cotabato, a non-formal pre-survey was carried out between September and November 2024. Informal, unstructured interviews were conducted with either the staff or owners of five agricultural veterinary supply stores, totaling 25 stores in each municipality. No formal questionnaire was used; instead, conversations focused on identifying the antibiotics most frequently purchased by local poultry and livestock farmers. Based on the responses, six antibiotics were consistently reported and subsequently selected for residue analysis in this study: trimethoprim/sulfamethoxazole, norfloxacin, doxycycline, amoxicillin, enrofloxacin, and tilmicosin.

Sample collection and preparation

A total of 36 whole raw dressed chickens—18 labeled as organic and 18 as non-organic—were collected between September and November 2024 from public wet markets in the six municipalities comprising the PPALMA area (Pigcawayan, Pikit, Alamada, Libungan, Midsayap, and Aleosan) in North Cotabato, Philippines. Only one primary public wet market in each municipality was sampled, as these serve as the sole poultry trading hubs in their respective localities. Chickens sold in supermarkets, groceries, or commercial malls were excluded to ensure consistency in vendor type and consumer purchasing environments.

In each market, three organic and three non-organic chickens were purchased, yielding six chickens per municipality and 36 chickens in total. This sample size was informed by comparable poultry residue studies in the Philippines and Southeast Asia (Ong et al. 2025), which used similar ranges (30-50 chickens) to identify residue occurrence patterns while balancing resource availability and laboratory processing capacity. Random purchasing was carried out across different stalls, simulating typical consumer behavior. Vendors were unaware of the scientific purpose of the purchases, ensuring that the collection process reflected natural market conditions.

Organic chickens were obtained from vendors who verbally claimed that their products were raised without synthetic antibiotics. While labeled as organic at the point of sale, no certification or documentation was available. Based on vendor accounts and market observation, these chickens were assumed to originate from smallholder or backyard farms within the municipalities. In contrast, non-organic chickens were purchased from stalls selling commercially branded halal poultry sourced from large-scale integrators outside North Cotabato, where antibiotic use in intensive farming systems is more common.

Each whole chicken was subdivided into leg and wing portions using sterile instruments, producing 72 tissue samples (36 legs and 36 wings). To maintain aseptic conditions, new disposable gloves were used for each dissection, cutting surfaces and tools were disinfected with 70% ethanol between samples, and tissue portions were placed in sterile, labeled zip-lock bags. Samples were transported in insulated coolers with ice packs and stored at -20°C until further analysis.

Initial sample processing

Prior to extraction, frozen samples were thawed at room temperature under controlled laboratory conditions. From each anatomical part, 50-100 g of meat were cut into small pieces using clean, sterilized knives and cutting boards. The meat was homogenized using a mechanical blender disinfected with 70% ethanol before and after each use. From each homogenized sample, 5-10 g were accurately weighed using an analytical balance and transferred into sterile, labeled containers. Sample labels included identifiers for the production type (organic or non-organic), anatomical part (wing or leg), and source municipality.

Extraction of antibiotic residues

Antibiotic residues in chicken meat were extracted using a modified QuEChERS method in accordance with AOAC Official Method 2007.01 (AOAC 2007), which is widely validated for multi-residue analysis of veterinary drugs in food matrices (Lehotay et al. 2005, 2010) and has been successfully applied and further refined for veterinary-drug residue screening (Masiá et al. 2016; Yang et al. 2024). Briefly, 5 g of homogenized chicken muscle tissue was mixed with 10 mL of acetonitrile containing 5% formic acid. A salting-out step was performed by adding 4 g magnesium sulfate, 1 g sodium chloride, 1 g trisodium citrate, and 0.5 g sodium hydrogencitrate sesquihydrate, followed by vortexing and centrifugation at 4,000 rpm for 10 minutes. The upper organic layer was subjected to dispersive solid-phase extraction (d-SPE) using C18 sorbent and anhydrous sodium sulfate to remove lipids and proteins, following methods similar to recently validated multi-residue QuEChERS procedures (Guo et al. 2022). The cleaned extract was evaporated under a nitrogen stream and reconstituted in 1 mL of methanol:water (1:1, v/v) for instrumental analysis.

LC-MS/MS detection and quantification

Quantitative analysis was performed using a Waters Xevo TQ-S Micro triple quadrupole mass spectrometer with an Acquity UPLC system and electrospray ionization (ESI) source, consistent with protocols described in recent veterinary drug residue studies (Waters Corporation 2021; Guo et al. 2022). Chromatographic separation was achieved on a C18 column (150×2.1 mm, 3 μm) with a mobile phase gradient of methanol and water (both containing 0.1% formic acid), at a flow rate of 0.3 mL/min. Injection volume was 10 μL and the column temperature was maintained at 40°C. The instrument operated in both positive and negative ion modes using Multiple Reaction Monitoring (MRM), in line with Codex and EMA guidelines for confirmatory analysis of veterinary residues (CAC 2021; EMA 2022).

Method validation, detection thresholds, and compliance standards

The method was validated for linearity ($R^2>0.99$), selectivity, precision, and accuracy using matrix-matched calibration standards, following international recommendations (CAC 2021; EMA 2022). Identification relied on retention times and ion transition matching, while Limits of Detection (LOD) and Limits of Quantification (LOQ) were calculated at signal-to-noise ratios of 3 and 10, respectively (Guo et al. 2022). Across all analytes, LODs ranged from 0.25 to 1.5 μg/kg, and LOQs ranged from 1 to 5 μg/kg. These parameters align with the Bureau of Animal Industry's (BAI 2021) national residue monitoring program, the European Medicines Agency (EMA 2022), and Codex Alimentarius standards (CAC 2021).

To define "positive" samples, antibiotic presence above the LOD threshold was used as the detection criterion, while compliance was assessed against the corresponding Maximum Residue Limits (MRLs) of 100 μg/kg for doxycycline and enrofloxacin and 50 μg/kg for tilmicosin (EMA 2022). Analytical procedures and quality control measures followed Philippine Department of Agriculture Standard Operating Procedures—SOP-8015 (Tetracyclines in Food and Milk), SOP-8041 (Fluoroquinolones, Macrolides, Sulfonamides), and SOP-8042 (Amoxicillin and β-lactams) (DA-BAI 2021).

Statistical analysis

All data analyses were performed using IBM SPSS Statistics version 27 (IBM Corp 2020). Descriptive statistics summarized the frequency and concentration of antibiotic residues. To assess the effect of production type (organic vs. non-organic) and anatomical part (leg vs. wing), a two-way analysis of variance (ANOVA) was performed, with assumptions checked using the Shapiro-Wilk test for normality and Levene's test for homogeneity of variances (Field 2018). A significance level of $p<0.05$ was applied.

Additionally, Chi-square tests of independence were conducted to evaluate whether detection frequencies varied significantly by production type and municipality. Antibiotics were categorized as "detected" or "not detected" based on whether concentrations exceeded the instrument's LOD. This approach follows standard practices in food residue surveillance studies (Barroga et al. 2020; Dimaapi et al. 2025).

Ethical statement

This study did not involve the use of live animals or human participants. All poultry meat samples were obtained post-slaughter through anonymous and non-invasive purchases at public wet markets across the selected municipalities in North Cotabato. The chickens were already processed and displayed for retail sale, with no direct interaction with live animals, poultry handlers, or consumers. No formal interviews or structured questionnaires were conducted during the procurement process, as the researchers acted as regular market consumers.

Given that the study did not involve live animal experimentation or human subject involvement, ethical clearance from an Institutional Animal Care and Use Committee (IACUC) or Institutional Review Board (IRB) was not required. Nevertheless, all sample handling and laboratory procedures adhered strictly to the institutional biosafety guidelines and the ethical standards outlined by the University's Research Ethics Committee. The research was conducted in accordance with the Philippine Food Safety Act of 2013 (Republic Act 10611), which provides the legal framework for food safety surveillance, and the Philippine National Antimicrobial Resistance (AMR) Action

Plan 2019-2023 (DOH-DA 2019), which prioritizes antimicrobial residue monitoring in livestock and poultry systems. Compliance was also guided by the Commission on Higher Education (CHED) Memorandum Order No. 20, series of 2021, which sets ethical standards for research conducted in higher education institutions in the Philippines.

RESULTS AND DISCUSSION

Detection and distribution of antimicrobial residues in chicken meat

Antimicrobial residue screening revealed a widespread occurrence of tetracyclines in chicken meat samples from public wet markets across six municipalities in North Cotabato, Philippines. Doxycycline, belonging to the tetracycline class of antibiotics, was the most prevalent residue, detected in all non-organic samples (100%) and in half of the organic samples (50%) (Table 1). This pattern underscores the persistent or indiscriminate use of tetracyclines and possible environmental contamination routes.

In non-organic samples, fluoroquinolone residues (enrofloxacin/norfloxacin) were detected in 66.7% and macrolide residues (tilmicosin) in 50% of samples. These compounds were completely absent in organic samples, suggesting production-type differences in antibiotic use and possible tissue accumulation patterns. Notably, none of the samples—whether organic or non-organic—tested positive for antifolates (trimethoprim/sulfamethoxazole) or β-lactams (amoxicillin), which may reflect reduced usage, rapid tissue degradation, or improved compliance with withdrawal practices in recent production cycles.

Quantitative residue levels and spatial variability

Residue concentrations measured via LC-MS/MS were compared to Maximum Residue Limits (MRLs) set by the European Medicines Agency (EMA 2021-2022), which are also adopted by Philippine regulatory bodies such as the Bureau of Animal Industry (BAI 2021). For reference, MRLs are 100 µg/kg for doxycycline and enrofloxacin, and 50 µg/kg for tilmicosin.

The color-encoded visualization (Figure 1) highlights clear geographic and production-type differences in antibiotic residues across the six municipalities. Doxycycline was the most consistently detected compound, with notably elevated levels in non-organic samples from Pikit (37.2 µg/kg in leg, 22.5 µg/kg in wing) and Pigkawayan (18.2 µg/kg in leg, 12.0 µg/kg in wing). Organic samples also contained doxycycline, though at lower levels, with Pigkawayan (20.1 µg/kg in leg, 9.5 µg/kg in wing) and Alamada (6.9 µg/kg in leg, 3.5 µg/kg in wing) being the most affected. In contrast, no doxycycline residues were detected in organic or non-organic samples from Libungan, suggesting stricter adherence to withdrawal periods or reduced antimicrobial usage in this municipality.

Enrofloxacin residues (fluoroquinolones) were exclusively detected in non-organic leg tissues, again concentrated in Pikit (10.8 µg/kg), Pigkawayan (7.6 µg/kg), and Alamada (3.9 µg/kg). Similarly, Tilmicosin (macrolide class) was restricted to non-organic leg tissues, with the highest levels found in Pikit (2.7 µg/kg) and Pigkawayan (2.4 µg/kg). These residues were entirely absent in organic samples, supporting vendor claims of reduced antibiotic use in smallholder systems.

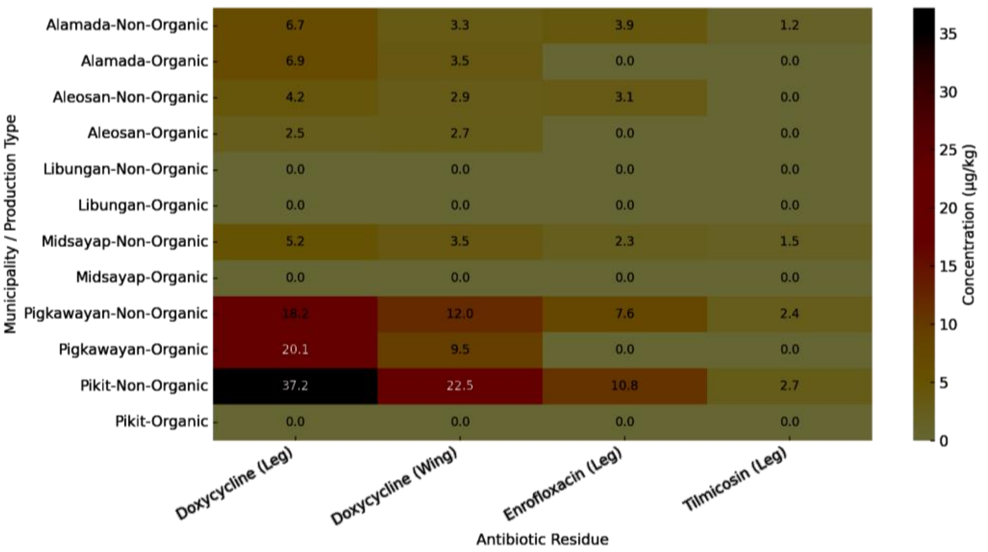

Figure 1. Color-encoded visualization of antibiotic residue concentrations (µg/kg) in organic and non-organic chicken meat across six municipalities in North Cotabato, Philippines. Warmer colors (yellow to red) indicate higher residue concentrations, while darker shades near zero reflect low or non-detectable levels (<1.5 µg/kg, represented as 0 for visualization). Residues measured include doxycycline, enrofloxacin, and tilmicosin across different tissue types (leg, wing) and production systems (organic, non-organic). Scale bar: Light yellow: Near detection threshold (<1.5 µg/kg), deep red: High residue concentration (~40 µg/kg)

Table 1. Detection frequency (%) of antibiotic residues in chicken meat samples (n=36)

Antibiotic class	Representative drug	Non-Organic (n=18)	Organic (n=18)
Tetracycline	Doxycycline	100%	50%
Fluoroquinolone	Enrofloxacin/ Norfloxacin	66.7%	0%
Macrolide	Tilmicosin	50%	0%
Antifolate	Trimethoprim/ Sulfamethoxazole	0%	0%
β-lactam	Amoxicillin	0%	0%

Although all detected concentrations remained below established MRLs, the clustering of high values in Pikit and Pigkawayan underscores their role as potential antibiotic-use hotspots in conventional poultry production. Conversely, the consistent absence of detectable residues in Libungan highlights local management differences that may reflect variations in veterinary oversight, farm practices, or market sourcing.

Residue levels in organic vs. non-organic samples

When results were aggregated by production type, a distinct pattern emerged between organic and non-organic chicken meat (Figure 2). Non-organic samples consistently showed higher residue concentrations across all antibiotic classes. Doxycycline was universally present in non-organic samples (100%), with the highest concentrations recorded in Pikit (37.2 µg/kg), followed by Pigkawayan and Alamada. Enrofloxacin and tilmicosin were also detected exclusively in non-organic leg tissues, reinforcing their association with intensive, conventional production systems.

In contrast, organic chicken samples were entirely free of fluoroquinolone and macrolide residues, supporting the premise of reduced antibiotic use in less intensive systems. However, doxycycline residues were still detected in organic chickens from Pigkawayan (20.1 µg/kg), Alamada (6.9 µg/kg), and Aleosan (2.5 µg/kg). Although these concentrations were well below the established Maximum Residue Limit (100 µg/kg), their presence in vendor-claimed "organic" products raises serious concerns about authenticity, traceability, and enforcement of organic standards. Since organic classification in this study was based solely on vendor declarations without third-party certification, these findings underscore the urgent need for stricter oversight and verification mechanisms to protect consumers and maintain confidence in organic labeling.

Together, Figure 1 highlights municipality- and tissue-level variability, identifying Pikit and Pigkawayan as consistent hotspots, while Figure 2 provides a broader system-level comparison that clearly distinguishes between organic and non-organic production. This dual approach strengthens the interpretation of results by revealing both localized residue patterns and overarching production-related differences.

Comparative analysis of antibiotic residue concentrations by production type and chicken part

To determine whether production method and anatomical part significantly influenced the concentration of antibiotic residues in chicken meat, a two-way analysis of variance (ANOVA) was performed. The results, presented in Table 2, indicated that neither chicken part (p=0.780) nor rearing practice (p=0.205) had a statistically significant effect on the mean residue concentrations. Specifically, the p-value of 0.780 for chicken part suggests that there were no significant differences in antibiotic concentrations between the leg and wing samples. These findings suggest that within the scope of this study, neither anatomical location nor declared rearing practice significantly affected the detected residue levels. Although these differences were not statistically significant, the biological implications remain important—particularly the detection of residues in samples labeled as organic.

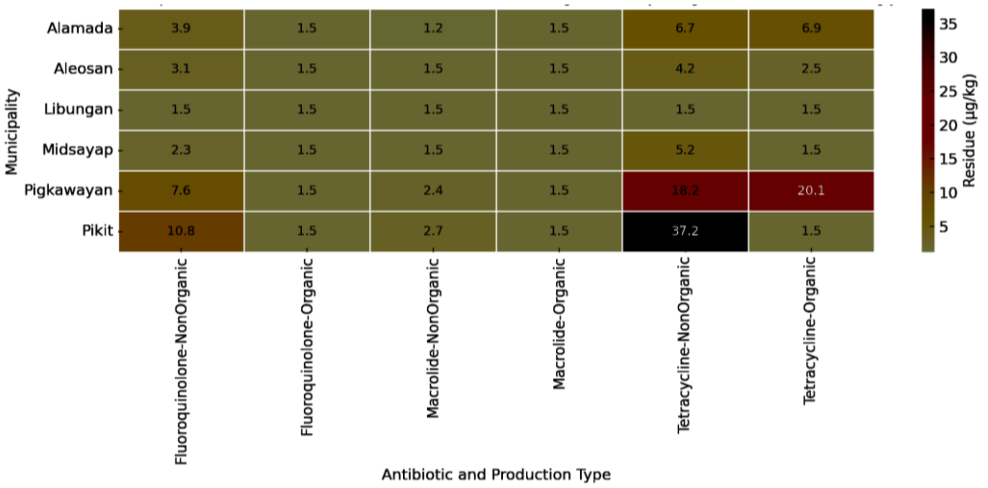

Figure 2. Color-encoded matrix of average antibiotic residue concentrations (µg/kg) in organic and non-organic chicken meat across six municipalities in North Cotabato, Philippines. Darker red shades indicate higher concentrations, while pale yellow shades reflect near-detection threshold values (<1.5 µg/kg, shown as 1.5 µg/kg for visualization). Residues measured include doxycycline (tetracycline class), enrofloxacin (fluoroquinolone class), and tilmicosin (macrolide class) across both production systems. Scale bar: Pale yellow: Low residue, orange: Moderate residue, red: High residue concentration

Statistical comparison of detection frequencies across municipalities and production types

In addition to the two-way ANOVA, which showed no significant differences in mean antibiotic residue concentrations by production type or anatomical part. a Chi-square test of independence was performed to determine whether antibiotic detection rates varied significantly by production system and municipality. Antibiotics were classified as "detected" if their concentration exceeded the instrument's LOD (limit of detection).

Table 3 revealed a statistically significant association between production type and detection frequency. Specifically, non-organic samples exhibited notably higher detection rates—100% for doxycycline, 66.7% for enrofloxacin, and 50% for Tilmicosin—compared to organic samples, where doxycycline was detected in only 50% and the other antibiotics were completely absent ($p<0.001$). These findings reflect the expected patterns of antibiotic use in conventional poultry systems, where routine prophylaxis and growth-promoting antimicrobials remain widespread.

Further analysis also demonstrated statistically significant variation across municipalities ($p=0.029$), with Pikit and Pigkawayan emerging as hotspots for antibiotic detection. This geographic disparity suggests local differences in antimicrobial usage practices, veterinary oversight, and possibly the intensity of poultry production systems. Targeted Chi-square tests conducted for enrofloxacin and tilmicosin detection by production type yielded additional strong associations ($p<0.001$), confirming that these residues were exclusively present in non-organic meat. These findings suggest geographic differences in antibiotic use, supply chain traceability, and potential weaknesses in veterinary oversight.

Discussion

The presence of antibiotic residues in chicken meat from wet markets in North Cotabato highlights continuing challenges in antimicrobial use, residue monitoring, and regulatory enforcement within smallholder poultry production systems. Although all detected residues were below the Maximum Residue Limits (MRLs) established by the Bureau of Animal Industry (BAI 2021) and international standards (CAC 2021), the repeated detection of doxycycline in both organic and non-organic samples points to weaknesses in withdrawal compliance, production oversight, and traceability mechanisms. Particularly troubling is the detection of doxycycline in half of the samples marketed as "organic," which undermines the credibility of organic labeling suggesting possible contamination, mislabeling, or non-compliance with certification standards. Comparable findings have been reported internationally (Cetinkaya et al. 2012; Bahmani et al. 2019), and more recent Philippine surveys and market-level testing continue to detect tetracycline residues in marketed chicken (Pineda-Cortel et al. 2024; Sabtula 2024; Ong et al. 2025). These results highlight that tetracyclines remain persistent in poultry production despite regulatory controls. In Southeast Asia, antimicrobial residues have been detected in meats marketed as organic, indicating that mislabeling or weak certification standards are a regional concern. Similarly, recent market-level studies in the Philippines have continued to report tetracycline residues in chicken, including samples labeled as "organic," highlighting that gaps in labeling, certification, and regulatory oversight are not unique to other countries (Taneja and Sharma 2019; Caneschi et al. 2023; Hedges et al. 2024; Pineda-Cortel et al. 2024; Sabtula 2024; Ong et al. 2025). Without reliable documentation and third-party audits, organic claims may mislead consumers who actively seek residue-free products. The absence of penicillin and antifolate residues in this study may be due to low levels of use in poultry farms in the region, or to their rapid degradation post-slaughter, as suggested in earlier pharmacokinetic studies.

Organic labeling fraud is increasingly recognized as a systemic challenge across global food systems. In the present study, vendors relied on self-declared claims without presenting certification or traceable documentation. This mirrors findings elsewhere. For example, Lehotay et al. (2025) in United States and Sabtula (2024) and Ong et al. (2025) in the Philippines described cases in which "organic" meats contained detectable antibiotic residues, demonstrating that weak certification oversight and inconsistent supply chain monitoring facilitate fraudulent or unverifiable labeling practices. Such practices not only mislead consumers but also undermine the efforts of farmers who comply with stricter production standards. While this study did not include farmer or vendor interviews that could directly confirm mislabeling practices, the convergence of evidence with other international studies suggests that systemic reforms are urgently needed. Measures such as third-party certification, QR-coded labeling, and active involvement of local government units (LGUs) and private sector actors in enforcing traceability would reduce the space for fraudulent practices and safeguard consumer confidence in organic products.

Table 2. Statistical comparison of antibiotic residue levels by chicken part and rearing practice

Factor	p-value
Chicken part	0.780
Rearing practice	0.205

Table 3. Chi-square test results comparing antibiotic detection frequency by production type and municipality

Factor	Chi-square (χ^2)	df	p-value
Production type (organic vs. non-organic)	21.60	1	<0.001
Municipality (6 sites)	12.41	5	0.029
Enrofloxacin detection (by production)	24.00	1	<0.001
Tilmicosin detection (by production)	18.00	1	<0.001

The detection of fluoroquinolone and macrolide residues exclusively in non-organic leg portions aligns with established practices in conventional poultry farming, where antibiotics are often administered prophylactically or for growth promotion, frequently without veterinary oversight (Rousham et al. 2018). The pharmacological properties of drugs like enrofloxacin and doxycycline—particularly their lipophilicity and vascular distribution—make it likely that they accumulate in muscle-dense tissues such as the leg (Anggriawan et al. 2024). This pattern has implications for residue testing protocols, since leg tissue may serve as a sentinel matrix in surveillance. Importantly, while detected concentrations did not exceed MRLs, both fluoroquinolones and macrolides are classified as critically important antimicrobials (CIAs) for human health (WHO 2022), and their presence in the food chain poses long-term risks for antimicrobial resistance.

Statistical analyses further highlighted systemic patterns in residue occurrence. While the two-way ANOVA did not show significant differences in mean concentrations between anatomical parts or rearing practices, Chi-square testing revealed significant disparities in detection frequencies between municipalities and production systems. This finding suggests that although concentrations may appear similar, the likelihood of detecting residues is substantially higher in non-organic poultry, consistent with the higher frequency of antibiotic use and weaker veterinary oversight in conventional production systems. The lack of significant differences between leg and wing tissues suggests relatively homogeneous tissue distribution, echoing pharmacokinetic evidence of systemic dispersion of tetracyclines and fluoroquinolones in poultry (Reyes-Herrera et al. 2005; Atef et al. 2020).

The biological detection of doxycycline in half of the organic-labeled samples raises further concerns about the integrity of organic labeling. Possible explanations include contamination from shared environments, inadequate withdrawal periods in farms claiming organic status, or outright misrepresentation by vendors. Comparable evidence has emerged internationally, with Lehotay et al. (2025) in the United States demonstrating residue persistence even under regulated systems. In the Philippines, recent market-level studies likewise detected tetracyclines and sulfonamides in retailed poultry, including products labeled as “organic” (Sabtula 2024; Ong et al. 2025), while local media reports highlight ongoing consumer risks and weak certification enforcement (Rappler 2024). Together, these findings underscore that organic-label verification gaps are not isolated incidents but part of a broader global and regional challenge, requiring systemic solutions rather than piecemeal interventions (Huong et al. 2020; Manning and Kowalska 2021; European Court of Auditors 2024).

From a governance perspective, these findings emphasize the urgent need for improved traceability, stronger certification systems, and localized residue surveillance programs. The variation in detection frequencies between municipalities—particularly in Pikit and Pigkawayan—demonstrates the uneven distribution of veterinary services, farmer knowledge of withdrawal periods, and access to regulated drugs. Such disparities mirror broader regional trends in Southeast Asia, where gaps in regulation and enforcement continue to hinder antimicrobial stewardship (ASEAN 2020).

At the national level, frameworks such as Republic Act No. 10611 (Food Safety Act) and the Department of Agriculture’s Antimicrobial Resistance (DA-AMR) Action Plan (2019-2023) provide the legal foundation for responsible antimicrobial use. However, their implementation remains inconsistent, especially in rural provinces like North Cotabato, where weak enforcement and gaps in monitoring systems have allowed antibiotic residues to persist in retail poultry products (Mahusay and Sepelagio 2023). The lack of accredited laboratories, limited numbers of veterinarians, and insufficiently trained extension officers undermine monitoring efforts. In practice, limited engagement by the BAI and FDA in local wet markets has allowed unchecked organic claims to proliferate.

Economic constraints exacerbate the problem. Many smallholder poultry farmers operate with little capital, often outside formal supply chains, and depend on agro-veterinary stores for advice. Without access to affordable testing or veterinary guidance, these farmers are less able to comply with regulations or manage withdrawal periods properly. Punitive approaches alone risk alienating these producers. As Mottet and Tempio (2017) and FAO (2021) argue, sustainable food safety governance must balance regulation with supportive mechanisms. Farmer cooperatives, mobile veterinary outreach, and affordable testing kits could help farmers voluntarily comply with residue standards while maintaining livelihoods.

The public health implications are significant. Chronic exposure to low levels of residues—especially fluoroquinolones and macrolides—has been linked to alterations in gut microbiota, allergic reactions, and increased antimicrobial resistance (Patangia et al. 2022). Given that both classes are classified by WHO (2022) as highest-priority CIAs for human health, their continued unregulated use in poultry threatens both animal and human populations. Moreover, antibiotic residues in poultry waste, when disposed of improperly, contribute to the environmental spread of resistance genes into soil and water ecosystems (Kemper 2008; Zhang et al. 2024).

This study has several limitations. The absence of farmer-level interviews or structured surveys on knowledge, attitudes, and practices limited the ability to link residue occurrence with farm behaviors. Likewise, vendor and consumer awareness were not directly assessed, and no visible labeling or certification was observed in the markets sampled. This omission constrained the capacity to contextualize residue findings with behavioral or socioeconomic factors. Furthermore, the classification of “organic” relied entirely on vendor claims without third-party validation, leaving the possibility of misclassification. Sampling was also limited to one primary market per municipality, which may not capture variability in smaller outlets or informal trade networks. While this reflects the actual market structure of the PPALMA area, it narrows the scope for generalization. Nonetheless, these limitations point to critical areas for future research, including farm-level validation, consumer-side assessments, and rural-urban market comparisons.

Preliminary outreach in this study, limited to sharing results informally with market vendors and municipal agriculture officers, helped raise awareness about antibiotic residues but lacked structured dissemination. Future efforts should prioritize participatory workshops, local dialogues, and public awareness campaigns to ensure findings inform both policy and practice at the grassroots level.

Ultimately, strengthening antibiotic stewardship and food safety in Philippine poultry production requires coordinated and multi-sectoral strategies. Residue surveillance must be institutionalized at the municipal level through LGU-led mobile testing laboratories, supported by BAI and FDA. Organic labeling should be standardized and enforced, with mandatory third-party certification and QR-coded systems to ensure transparency. Farmer-focused training programs on withdrawal periods and responsible antibiotic use should be integrated into extension services, using accessible formats and local dialects. In parallel, the sale of veterinary antibiotics should be tightly regulated, requiring prescriptions and providing usage guidance.

In conclusion, while residue levels in this study did not exceed MRLs, the frequency of detection—especially in uncertified organic meat—exposes systemic vulnerabilities in regulation, certification, and market-level oversight. Addressing these risks requires coordinated involvement of regulatory bodies, LGUs, academic institutions, and the private sector. Two immediate interventions are particularly critical: first, mandating third-party organic certification for all poultry vendors in wet markets, and second, establishing LGU-led mobile testing laboratories for routine residue monitoring. When combined with farmer-centered training and stronger veterinary regulation, these measures can reduce misuse, restore consumer trust, and strengthen the resilience of smallholder poultry systems in the Philippines.

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REFERENCES

Ager EO, Carvalho T, Silva EM, Ricke SC, Hite JL. 2023. Global trends in antimicrobial resistance on organic and conventional farms. Sci Rep 13: 22608. DOI: 10.1038/s41598-023-47862-7.

Anggriawan R, Lokapirnasari WP, Hidanah S, Al Arif MA, Candra DA. 2024. Residue detection of tylosin antibiotics and enrofloxacin in broiler chickens. Adv Anim Vet Sci 12 (11): 2195-2204. DOI: 10.17582/journal.aavs/2024/12.11.2195.2204.

AOAC [Association of Official Analytical Chemists]. 2007. Official Method 2007.01: Pesticide residues in foods by acetonitrile extraction and partitioning with magnesium sulfate. Association of Official Analytical Chemists.

ASEAN [Association of Southeast Asian Nations]. 2020. ASEAN guidelines for the prudent use of antimicrobials in livestock. ASEAN Secretariat. https://asean.org/book/asean-guidelines-antimicrobials-livestock.

Atef M, El-Banna HA, Elzorba HY, Soliman AM. 2020. Pharmacokinetics and tissue residue of enrofloxacin in healthy, *Eimeria*-infected broiler chickens and those pre-treated with amprolium and toltrazuril. Intl J Vet Sci Med 8 (1): 31-38. DOI: 10.1080/23144599.2020.1765720.

Bahmani K, Shahbazi Y, Nikousefat Z. 2019. Monitoring and risk assessment of tetracycline residues in foods of animal origin. Food Sci Biotechnol 29 (3): 441-448. DOI: 10.1007/s10068-019-00665-x.

Baldrias LR, Gatchalian-Yee M, Raymundo AK. 2021. Detection of antibiotic residues in dressed chicken from commercial and backyard producers using four plate test. Philipp J Vet Med 45 (1): 39-48.

Barroga TRM, Morales RG, Benigno CC, Castro SJM, Caniban MM, Cabullo MFB, Agunos A, de Balogh K, Dorado-Garcia A. 2020. Antimicrobials used in backyard and commercial poultry and swine farms in the Philippines: A qualitative pilot study. Front Vet Sci 7: 329. DOI: 10.3389/fvets.2020.00329.

BAI [Bureau of Animal Industry]. 2021. National residue monitoring program: Annual report. Department of Agriculture, Philippines.

Calagui RT. 2016. Occurrence of antibiotic residue in edible tissues of broiler chicken sold in Tuguegarao City, Philippines. Interdiscip Res J 1 (1): 17-30.

Caneschi A, Bardhi A, Barbarossa A, Zaghini A. 2023. The use of antibiotics and antimicrobial resistance in veterinary medicine, a complex phenomenon: A narrative review. Antibiotics 12 (3): 487. DOI: 10.3390/antibiotics12030487.

Cetinkaya F, Yibar A, Soyutemiz GE, Okutan B, Ozcan A, Karaca MY. 2012. Determination of tetracycline residues in chicken meat by liquid chromatography-tandem mass spectrometry. Food Addit Contam Part B Surveill 5: 45-49. DOI: 10.1080/19393210.2012.655782.

CAC [Codex Alimentarius Commission]. 2021. Maximum residue limits (MRLs) for veterinary drugs in foods. Food and Agriculture Organization, Rome. http://www.fao.org/fao-who-codexalimentarius.

DA-BAI [Department of Agriculture - Bureau of Animal Industry]. 2021. Standard operating procedures for veterinary drug residue analysis. Department of Agriculture, Philippines.

DOH-DA [Department of Health - Department of Agriculture]. 2019. Philippine National Antimicrobial Resistance Action Plan 2019-2023. DOH-DA, Manila. https://doh.gov.ph/national-amr-action-plan.

Dimaapi LKA, Dela Cruz ALG, Francisco RAD, Noble RGD, Sabangan HEG, Gavino-Lacuna AR, Lota MMM. 2025. Antimicrobial resistance profile of Escherichia coli isolated from raw chicken meat in a selected wet market in Manila City, Philippines. Acta Med Philipp 59 (9): 107-122. DOI: 10.47895/amp.vi0.8383.

European Court of Auditors. 2024. Special report 19/2024: Organic farming in the EU. Publications Office of the European Union. https://www.eca.europa.eu/en/publications

EMA [European Medicines Agency]. 2022. MRLs summary report: Maximum residue limits for veterinary medicinal products. https://www.ema.europa.eu/en/veterinary-regulatory.

Field A. 2018. Discovering statistics using IBM SPSS statistics (5th ed.). SAGE Publications, Newbury Park.

FAO [Food and Agriculture Organization]. 2002. Annex VI: Issues and Policy Options for Addressing Environmental and Human Health Risks Associated with Growth in Small- and Large-Scale Swine and Poultry Production in the Philippines. Food and Agriculture Organization of the United Nations, Rome. https://www.fao.org/4/x6115e/x6115e0g.htm.

FAO [Food and Agriculture Organization]. 2021. Tackling antimicrobial use and resistance in poultry: FAO support for responsible antimicrobial use in poultry production. FAO, Rome. DOI: 10.4060/cc9185en.

Guo X, Li Y, Zhao J, Wang Z. 2022. Rapid determination of 103 common veterinary drug residues in chicken muscle using QuEChERS with dispersive solid-phase extraction clean-up incorporating C18 and anhydrous sodium sulfate. Food Chem 380: 132146. DOI: 10.1016/j.foodchem.2022.132146.

Hedges S, Pelligand L, Chen L, Seow K, Hoang TT, Luu HQ, Dang STT, Pham NT, Pham HTT, Cheah YC, Wang Y, Hurtaud-Pessel D, Conan A, Fournié G, Blake D, Tomley F, Conway PL. 2024. Antimicrobial residues in meat from chickens in Northeast Vietnam: Analytical validation and pilot study for sampling optimisation. J Consum Prot Food Saf 19: 225-234. DOI: 10.1007/s00003-024-01478-9.

Huong LQ, Hang TTT, Ngoc PT, Tuat CV, Erickson VI, Padungtod P. 2020. Pilot monitoring of antimicrobial residues in chicken and pork in Vietnam. J Food Prot 83 (10): 1701-1706. DOI: 10.4315/JFP-20-111.

IBM Corp. 2020. IBM SPSS Statistics for Windows (Version 27.0) [Computer software]. IBM Corp.

Imperial IC, Pabustan PM, Valencia KA, Nicdao MA, Ibana J. 2022. Emergence of resistance genes in fecal samples of antibiotic-treated Philippine broilers emphasizes the need to review local farming practices. Trop Biomed 39 (1): 150-159. DOI: 10.47665/tb.39.1.020.

Kemper N. 2008. Veterinary antibiotics in the aquatic and terrestrial environment. Ecol Indic 8: 1-13. DOI: 10.1016/j.ecolind.2007.06.002.

Lehotay SJ, Maštovská K, Lightfield AR. 2005. Use of buffering and other means to improve results of problematic pesticides in a fast and easy method for residue analysis of fruits and vegetables. J AOAC Intl 88 (2): 615-629. DOI: 10.1093/jaoac/88.2.615.

Lehotay SJ, Mastovská K, Lightfield AR, Gates RA. 2010. Multi-analyst, multi-matrix performance of the QuEChERS approach for pesticide residues in foods and feeds using HPLC-MS/MS analysis with different calibration techniques. J AOAC Intl 93 (2): 355-367. DOI: 10.1093/jaoac/93.2.355.

Lehotay SJ, Michlig N, Lightfield AR, Domesle A, Wiggins S, Duverna R, Weyrauch K, Green JE, Zipperer L. 2025. Antibiotic residues in cattle reported to be raised without antibiotics. J Agric Food Chem 73 (1): 847-860. DOI: 10.1021/acs.jafc.4c07440.

Mahusay J, Sepelagio E. 2023. Sensitivity of microbial inhibition assay for screening antibiotic residues in retailed meats collected from the public market of Kabacan, Cotabato, Philippines. J Food Saf Hyg 9 (2): 88-98. DOI: 10.18502/jfsh.v9i2.13422.

Manning L, Kowalska A. 2021. Considering fraud vulnerability associated with credence-based products such as organic food. Foods 10 (8): 1879. DOI: 10.3390/foods10081879.

Masiá A, Morales-Suárez-Varela MM, Llopis-González A, Picó Y. 2016. Determination of pesticides and veterinary drug residues in food by liquid chromatography-mass spectrometry: A review. Anal Chim Acta 892: 40-61. DOI: 10.1016/j.aca.2016.07.023.

Mottet A, Tempio G. 2017. Global poultry production: Current state and future outlook and challenges. World's Poult Sci J 73 (2): 245-256. DOI: 10.1017/S0043933917000071.

Ong MTYM, Santos CC, Soriano AP. 2025. Detection of antibiotic residues in leg quarter of chickens slaughtered in accredited poultry dressing plants in Nueva Ecija, Philippines. ARSHI Vet Lett 9 (2): 31-32. DOI: 10.29244/avl.9.2.31-32.

Patangia DV, Anthony Ryan C, Dempsey E, Paul Ross R, Stanton C. 2022. Impact of antibiotics on the human microbiome and consequences for host health. MicrobiologyOpen 11: e1260. DOI: 10.1002/mbo3.1260.

Pineda-Cortel MR, del Rosario EH, Villaflores OB. 2024. Use of veterinary medicinal products in the Philippines: regulations, impact, challenges, and recommendations. J Vet Sci 25 (2): e33. DOI: 10.4142/jvs.23134.

Rappler. 2024. Negros Island confronts growing threat of food fraud in organic farming. https://www.rappler.com/philippines/visayas/negros-island-growing-threat-food-fraud-organic-farming/

Republic Act No. 10611. 2013. The Food Safety Act of 2013. Congress of the Philippines, Manila.

Reyes-Herrera I, Schneider MJ, Cole K, Farnell MB, Blore PJ, Donoghue DJ. 2005. Concentrations of antibiotic residues vary between different edible muscle tissues in poultry. J Food Prot 68 (10): 2217-2219. DOI: 0.4315/0362-028x-68.10.2217.

Rousham EK, Unicomb L, Islam MA. 2018. Human, animal and environmental contributors to antibiotic resistance in low-resource settings: Integrating behavioural, epidemiological and One Health approaches. Proc Biol Sci 285 (1876): 20180332. DOI: 10.1098/rspb.2018.0332.

Sabtula BU. 2024. Determination of chlortetracycline residue in chicken (*Gallus gallus domesticus*, Family: Phasianidae) meat products from public markets of Zamboanga City. Sci Asia Rev 9 (1): 84-110.

Senate of the Philippines. 2019. Revilla seeks stricter implementation of Food Safety Act of 2013. https://legacy.senate.gov.ph/press_release/2019/1106_revilla1.asp.

Taneja N, Sharma M. 2019. Antimicrobial resistance in the environment: The Indian scenario. Indian J Med Res 149 (2): 119-128. DOI: 10.4103/ijmr.IJMR_331_18.

Van Boeckel TP, Brower C, Gilbert M, Grenfell BT, Levin SA, Robinson TP, Laxminarayan R. 2019. Global trends in antimicrobial resistance in animals in low- and middle-income countries. Science 365 (6459): eaaw1944. DOI: 10.1126/science.aaw1944.

Waters Corporation. 2021. Performance of the Xevo TQ-S cronos with UPLC I-Class PLUS system for quantitative determination of banned veterinary drug residues in chicken muscle. Waters Application Note. https://www.waters.com/content/dam/waters/en/app-notes/2021/720007233/720007233-en.pdf.

WHO [World Health Organization]. 2014. Antimicrobial resistance: Global report on surveillance. World Health Organization, Geneva. https://www.who.int/publications/i/item/9789240062702.

WHO [World Health Organization]. 2022. Critically important antimicrobials for human medicine, 7th revision 2022. WHO, Geneva.

Yang G, Zhang J, Tang Y, Kong C, Li S, Wang S., Ding S, Gu L, Shen X, Martin AA, Chi H. 2024. Development and validation of rapid screening of 192 veterinary drug residues in aquatic products using HPLC-HRMS coupled with QuEChERS. Food Chem 22: 101504. DOI: 10.1016/j.fochx.2024.101504.

Zhang Y, Wang N, Wan J, Jousset A, Jiang G, Wang X, Wei Z, Xu Y, Shen Q. 2024. Exploring the antibiotic resistance genes removal dynamics in chicken manure by composting. Bioresour Technol 410: 131309. DOI: 10.1016/j.biortech.2024.131309.